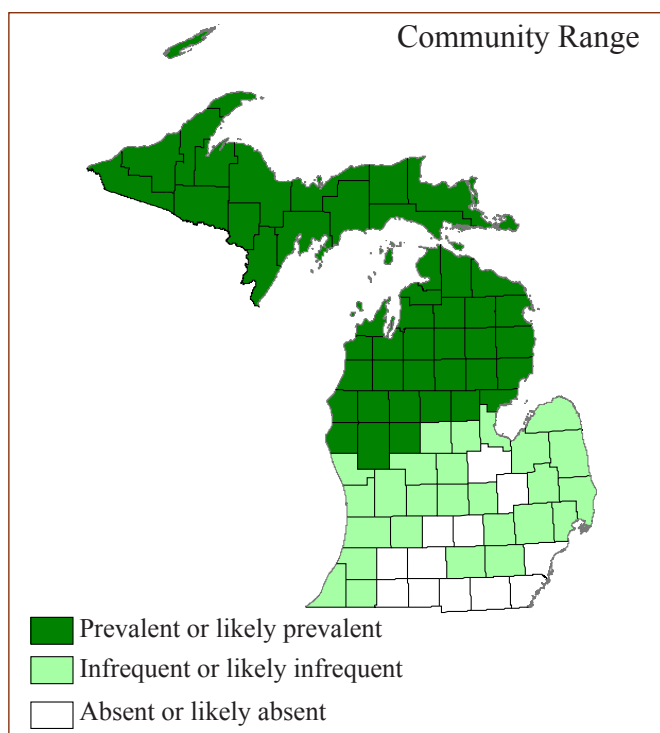




Photo by Michael R. Penskar



Overview: Rich conifer swamp is a groundwater-influenced, or minerotrophic, forested wetland that is dominated by northern white cedar (*Thuja occidentalis*) and occurs on organic soils (e.g., peat and muck). The community is often referred to as cedar swamp.

Global and State Rank: G4/S3

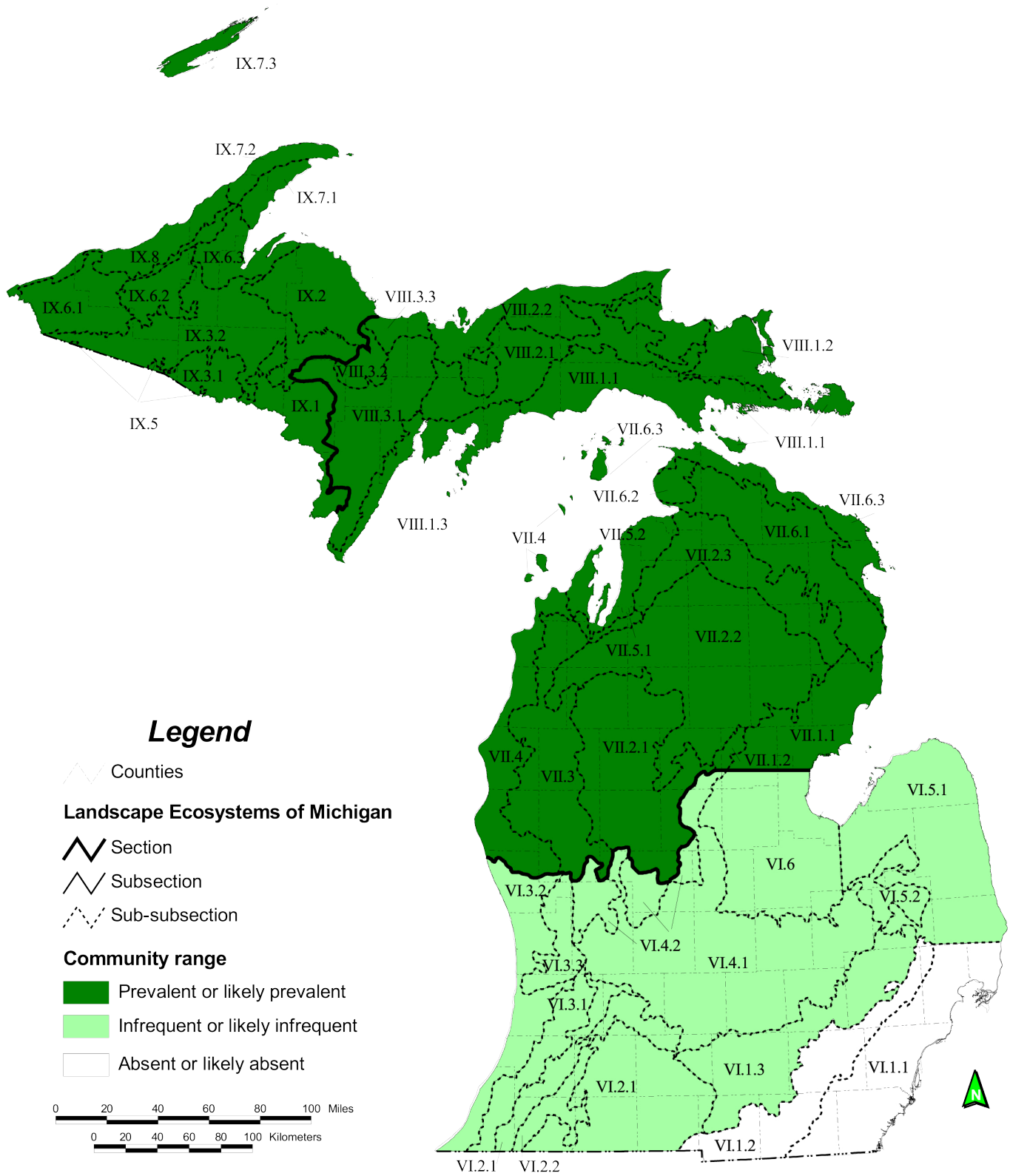
Range: Rich conifer swamp occurs throughout the upper Midwest and northeast United States and adjacent Canadian provinces (Faber-Langendoen 2001, NatureServe 2001). The community varies in overall species composition across its range, which includes Michigan, Minnesota, Wisconsin, Ontario, Manitoba, Quebec, New York, New Hampshire, Vermont, Maine, and northern Illinois, Indiana and Ohio (Faber-Langendoen 2001, NatureServe 2001). In Michigan, rich conifer swamp occurs primarily north of the climatic tension zone, in northern Lower Michigan and the Upper Peninsula.

Several other conifer-dominated natural communities also occur in Michigan and can be easily distinguished from northern white cedar-dominated, minerotrophic rich conifer swamp. A similar community, rich tamarack swamp, which is dominated by tamarack (*Larix laricina*) instead of northern white cedar, occurs primarily south of the tension zone (Kost 2001a). Both

communities are minerotrophic wetlands but differ in species composition because of the absence of northern white cedar, which often forms a dense canopy. Another type of conifer-dominated wetland, poor conifer swamp, which occurs primarily in northern Michigan, can be distinguished from rich conifer swamp by its acidic organic soils, lack of groundwater influence (i.e., ombrotrophic), and prevalence of black spruce (*Picea mariana*) and/or tamarack (Kost et al. 2007). Stands of mixed conifers and hardwoods that occur on saturated mineral or muck soils are classified as hardwood-conifer swamp and also occur primarily in northern Michigan (Kost et al. 2007). Boreal forest, which is often dominated by northern white cedar, is sometimes confused with rich conifer swamp. Unlike rich conifer swamp, most boreal forests in Michigan are upland communities that occur near the northern Great Lakes shoreline on thick duff (4 - 8 cm) over bedrock, abandoned cobblestone beach ridges, or sand.

Rank Justification: Accounts of past and present acreages of northern white cedar-dominated wetlands vary and are confounded by differences of interpretation between cedar swamp and other types of mixed conifer and hardwood-conifer wetlands. Analysis of General Land Office survey notes in Michigan reveals that cedar swamp once occupied over 500,000 hectares (1.2 million acres) (Comer et al. 1995). Areas of mixed





Ecoregional map of Michigan (Albert 1995) depicting distribution of rich conifer swamp (Albert et al. 2008)



conifer swamp, which in some locations included a significant proportion of northern white cedar, occupied an additional 1.2 million hectares (3 million acres) (Comer et al. 1995). Recent estimates of northern white cedar-dominated wetlands in Michigan range from nearly 500,000 hectares (1.2 million acres) (Raile and Smith 1980) to less than 22,000 hectares (54,000 acres) (MIRIS 1978). The large discrepancy between the two figures probably indicates that the MIRIS land cover data included many cedar swamps within the broader class of lowland conifer, which is estimated at over 600,000 hectares (1.5 million acres). At present, it is difficult to reliably determine the total acreage of rich conifer swamp. Historical evidence indicates that most cedar swamps in Michigan were logged during the late 1800s and many were subsequently burned-over in the slash fires that followed. Many of these swamps naturally regenerated in the early 1900s, when the region's white-tailed deer (*Odocoileus virginianus*) population was much smaller than at present (Van Deelen et al. 1996). Others were drained and used for agriculture or converted to different wetland types such as hardwood-conifer swamp, hardwood swamp, alder thicket, aspen, sedge meadow, fen, or bog.

Northern white cedar is highly prized for its durability when in contact with soil and moisture. In the past it was used extensively for railroad ties, posts, mine timbers, shingles, and siding (Hover 1990). Today, demand for northern white cedar lumber remains strong with current uses including shakes, shingles, posts, poles, pilings, and specialty products (Grossman and Potter-Witter 1990).

Cedar swamps provide habitat for many wildlife species including critical winter habitat for deer and snowshoe hare (Verme 1965, Doepker and Ozoga 1990). In Michigan's Upper Peninsula, more than eighty species of wildlife are known to use various seral stages of the community during some portion of their life cycle (Doepker and Ozoga 1990).

Landscape and Abiotic Context: Rich conifer swamp may occur in outwash channels, outwash plains, glacial lakeplains, and in depressions on coarse- to medium-textured ground moraines (Kost et al. 2007). It is common in outwash channels of drumlin fields and where groundwater seeps occur at the bases of moraines. Rich conifer swamp typically occurs in association with lakes and cold, groundwater-fed streams. It also occurs along

the Great Lakes shoreline in old abandoned embayments and in swales between former beach ridges (i.e., wooded dune and swale complex). The soils are composed of saturated, coarse woody peat and muck and may vary significantly in depth of organic matter. The organic soils are typically neutral to moderately alkaline but may be very strongly acid near the surface where sphagnum moss dominates the ground layer.

Climatic conditions in the community are influenced by its northerly distribution, low topographic position, and thick layer of mosses, especially sphagnum species, which insulate the organic soils. At night, cold air drains down from the surroundings uplands throughout the growing season, causing condensation to collect on plants. This constant source of nocturnal moisture helps sustain the community's abundant lichen and bryophyte flora (Curtis 1959). The cold air drainage may also cause nighttime temperatures to drop below freezing throughout the growing season (Curtis 1959). The insulating properties of sphagnum moss allow ice to remain within the upper layers of soil until mid-June or July, but in the fall, soils remain unfrozen until after snowfall and deep penetration of frost may not occur until February (Curtis 1959). Thus, rich conifer swamp has a shorter, cooler, and more humid growing season than the surrounding uplands.

Natural Processes: The structure and species composition of rich conifer swamp are strongly influenced by the constant flow of mineral-rich, cold groundwater through the organic soils (Christensen et al. 1959, Schwintzer 1981, Kudray and Gale 1997). Schwintzer (1981) determined that rich conifer swamps in northern Lower Michigan have very high levels of pH (7.0 - 7.4), total alkalinity (CaCO_3 , 129 - 167 $\text{mg} \cdot \text{L}^{-1}$), calcium (Ca, 28.1 to 50.0 $\text{mg} \cdot \text{L}^{-1}$), and magnesium (Mg, 10.5 - 13.1 $\text{mg} \cdot \text{L}^{-1}$) in comparison to bogs (i.e., ombrotrophic wetlands).

Seasonal water level fluctuations are common with water levels being highest in the spring and lowest in late summer and fall. While rich conifer swamp occurs on level terrain such as outwash plains, the microtopography of the ground layer is extremely varied, partly in response to seasonal water level fluctuations. The roots of northern white cedar and tamarack, another common species, form extensive mats that stand elevated above adjacent muck-flats or carpets of moss. During the spring, water typically fills the spaces between the root-



hummocks, while in summer and fall, exposed organic soil or moss (when present) occupy these areas.

Beaver flooding, fire, and windthrow are all important forms of natural disturbance for rich conifer swamp. Beaver flooding can cause extensive mortality of northern white cedar and other woody plants and significantly alter community structure and composition.

Fire may spread through the community during extensive periods of drought, killing many woody plants and in some instances, removing the upper layers of organic soil (Curtis 1959). However, fire can also play a role in the community's establishment. In Wisconsin, several cedar swamps are thought to have originated when seedlings of northern white cedar established directly on burned-over organic soils (Curtis 1959). In other instances, northern white cedar colonized alder thickets that originated when fire destroyed black spruce-tamarack swamp (i.e., poor conifer swamp) (Christensen et al. 1959). In addition, many cedar swamps in Michigan today occupy sites that burned during the slash fires of the logging era (Verme and Johnston 1986, Pregitzer 1990, Van Deelen et al. 1996).

Because of the anaerobic conditions associated with a high water table and organic soils, trees growing in rich conifer swamp are shallowly rooted. Thus, windthrow is a very common natural disturbance in cedar swamps. The resulting tip-up mounds, abandoned root pits, and coarse woody debris all contribute to the community's complex structure and microtopography. The tipping process is often gradual, with many leaning, bent, and fallen trees distributed throughout most stands. Windthrow may also facilitate regeneration of northern white cedar by creating opportunities for layering, and light gaps for seedlings and saplings.

Northern white cedar is especially well adapted to windthrow because of its ability to produce adventitious roots at both its base and branches. When a living northern white cedar is toppled by wind, a portion of its root system typically remains intact, and new, adventitious roots form where the lateral branches come in contact with the ground. As the new root system takes hold, the upward-facing lateral branches begin to grow, eventually forming a straight, closely packed row of trees. In addition, its lower branches may form adventitious roots when in contact with the forest floor or engulfed by sphagnum moss, eventually forming new, independent

trees. Northern white cedar has been observed colonizing poor conifer swamp through this type of layering (Christensen et al. 1959).



Photo by Michael A. Kost

Following windthrow, the lateral branches of northern white cedar can form new main stems, while the trunk and underlying branches become the new root system.

The ability of northern white cedar to reproduce both sexually (through seed) and asexually (through layering) adds an element of long-term stability to the community that is evidenced by the abundance of old northern white cedar logs within the peat profiles of many cedar swamps (Curtis 1959). Catastrophic fire and windfall in northern Lower Michigan conifer swamps are estimated to have occurred at intervals of approximately 3,000 years (Whitney 1986).

While northern white cedar seedlings can be very abundant in some swamps, vegetative propagation (e.g., layering) is much more prevalent than establishment through seed (Nelson 1951). Seedlings of northern white cedar require constant moisture and can successfully establish on a variety of substrates including rotten logs and stumps, sphagnum moss, and exposed organic soil (Curtis 1959, Holcombe 1976). However, moss-covered logs support the vast majority of seedlings because their elevated position provides a warmer microclimate for seed germination than the forest floor and protects them from seasonal flooding (Nelson 1951, Holcombe 1979). Excellent germination and establishment has also been observed following fire on organic soil (Curtis 1959, Verme and Johnston 1986).



Classical wetland succession proceeds with a bog mat slowly colonizing open water (Curtis 1959). Tamarack is the first tree species to colonize the loose peat of an advancing mat. Black spruce follows shortly afterwards as the peat becomes more firm and its water holding capacity is slightly reduced. The poor conifer swamps (i.e., treed bogs) that eventually form occur on the wettest of organic soil sites. As the peat continues to settle, its water holding capacity is gradually reduced and northern white cedar is then able to colonize poor conifer swamp. Further settling and reductions in the water holding capacity of the organic soils allows hardwoods to establish. Black ash (*Fraxinus nigra*) is one of the first hardwood species to invade cedar swamp followed by red maple (*Acer rubrum*) and yellow birch (*Betula alleghaniensis*). Once well established, hardwoods eventually overtop northern white cedar and assume dominance (Curtis 1959).

Observations of successional patterns in Wisconsin indicate that many cedar swamps formed on sites that previously supported alder thickets or black spruce-tamarack swamps (i.e., poor conifer swamp) (Curtis 1959). Conversely, in northern Lower Michigan, where the mineral rich, calcareous substrates and groundwater are high in alkalinity, most northern white cedar-dominated conifer swamps probably developed on sites that originally supported northern fen and not bog or poor conifer swamp (Schwintzer 1981).

Vegetation Description: The structure of rich conifer swamp is shaped by northern white cedar, the dominant tree species. Northern white cedar is a relatively short tree (20 m) and often forms a dense, low canopy, which can prevent other tree species from establishing (Curtis 1959). Because windthrow is very common, portions of the community often appear as a dense tangle of fallen, leaning, and misshapen northern white cedar. The complex community structure is further enhanced by the roots of northern white cedar and tamarack, which are often elevated above adjacent saturated or flooded organic soil, or carpets of moss.

In addition to northern white cedar, other common tree species may include: balsam fir (*Abies balsamea*), tamarack, black spruce, white spruce (*Picea alba*), hemlock (*Tsuga canadensis*), white pine (*Pinus strobus*), black ash, red maple, yellow birch, paper birch (*Betula papyrifera*), American elm (*Ulmus americana*), quaking aspen (*Populus tremuloides*), and balsam poplar (*Populus balsamifera*).

Shrubs can be very common, especially within recent windfalls. Tall shrub species occurring in rich conifer swamp include: alder (*Alnus rugosa*), winterberry (*Ilex verticillata*), mountain holly (*Nemopanthus mucronatus*), red-osier dogwood (*Cornus stolonifera*), elderberry (*Sambucus canadensis*), red elderberry (*Sambucus racemosa*), huckleberry (*Gaylussacia baccata*), autumn willow (*Salix serissima*) and Canada yew (*Taxus canadensis*). Presettlement accounts of the community's species composition list Canada yew as one of the most common understory species but this plant has since been extirpated from most cedar swamps as a result of herbivory by deer (Van Deelen et al. 1996). Balsam fir also commonly occurs as part of the shrub layer, sometimes forming dense patches.

Low shrub species common to rich conifer swamp can include: Labrador tea (*Ledum groenlandicum*), blueberry (*Vaccinium angustifolium*), bilberry (*V. myrtilloides*), leatherleaf (*Chamaedaphne calyculata*), American fly honeysuckle (*Lonicera canadensis*), hairy honeysuckle (*Lonicera hirsuta*), swamp fly honeysuckle (*Lonicera oblongifolia*), wild black currant (*Ribes americanum*), swamp red currant (*Ribes triste*), and swamp black currant (*Ribes lacustre*).

Common vine species in rich conifer swamp include poison ivy (*Toxicodendron radicans*) and red honeysuckle (*Lonicera dioica*).

The ground layer of rich conifer swamp can be especially diverse in sedges, ferns, orchids, liverworts and mosses. Common sedges include: *Carex gynocrates*, *C. leptalea*, *C. disperma*, *C. trisperma*, *C. interior*, *C. eburnea*, and *C. vaginata*. Common fern species include: maidenhair fern (*Adiantum pedatum*), lady fern (*Athyrium filix-femina*), rattlesnake fern (*Botrychium virginianum*), bulblet fern (*Cystopteris bulbifera*), spinulose woodfern (*D. carthusiana*), crested woodfern (*Dryopteris cristata*), glandular woodfern (*D. intermedia*), oak fern (*Gymnocarpium dryopteris*), sensitive fern (*Onoclea sensibilis*), cinnamon fern (*Osmunda cinnamomea*), marsh fern (*Thelypteris palustris*), broad beech-fern (*Thelypteris phegopteris*), and New York fern (*Thelypteris noveboracensis*). Common orchids include: early coralroot (*Corallorhiza trifida*), yellow lady's slipper (*Cypripedium calceolus*), showy lady's slipper (*Cypripedium reginae*), tall white bog orchid (*Platanthera dilatata*), blunt-leaved orchid (*Platanthera obtusata*), tall northern bog orchid (*Platanthera hyper-*





Rich conifer swamps are characterized by canopy dominance by cedar and high structural and floristic diversity. Top photo by Bradford S. Slaughter and bottom photo by Joshua G. Cohen.



borea), heart-leaved twayblade (*Listera cordata*) and broad-leaved twayblade (*L. convallarioides*). Additional common ground flora species include: wild sarsaparilla (*Aralia nudicaulis*), Jack-in-the-pulpit (*Arisaema triphyllum*), marsh marigold (*Caltha palustris*), small enchanter's nightshade (*Circaea alpina*), goldthread (*Coptis trifolia*), bunchberry (*Cornus canadensis*), water horsetail (*Equisetum fluviatile*), fragrant bedstraw (*Galium triflorum*), creeping snowberry (*Gaultheria hispidula*), wintergreen (*G. procumbens*), purple avens (*Geum rivale*), rattlesnake grass (*Glyceria canadensis*), fowl manna grass (*G. striata*), jewelweed (*Impatiens capensis*), wild blue flag (*Iris versicolor*), twinflower (*Linnaea borealis*), Canada mayflower (*Maianthemum canadense*), naked miterwort (*Mitella nuda*), one-flowered pyrola (*Moneses uniflora*), gay-wings (*Polygala paucifolia*), pink pyrola (*Pyrola asarifolia*), round-leaved pyrola (*Pyrola rotundifolia*), dwarf raspberry (*Rubus pubescens*), mad-dog skullcap (*Scutellaria lateriflora*), twisted-stalk (*Streptopus amplexifolius*), and starflower (*Trientalis borealis*).

Rich conifer swamps are characterized by a great diversity and abundance of mosses, lichens, and liverworts due the constant supply of nocturnal moisture, alkaline groundwater, heterogeneous ground-layer microtopography, and presence of sphagnum moss, which creates locally acidic conditions. The lichens and bryophytes are common throughout the forest floor and also grow as epiphytes on the trunks and branches of trees and shrubs. Holcombe (1976) studied the bryophytes associated with fallen trees in a rich conifer swamp in northern Lower Michigan and observed 50 species of moss and 20 species of liverworts growing on logs that supported seedlings of northern white cedar. The most frequently encountered mosses were the mat-forming species (i.e., pleurocarpous), *Callicladium haldanianum* and *Pleurozium schreberi*, which covered nearly the entire surfaces of most nurse logs. In some rich conifers swamps, sphagnum mosses may also cover large portions of the forest floor. Common species include *Sphagnum centrale*, *S. squarrosum*, *S. girgensohnii*, *S. wulfinaum*, *S. warnstorffii*, and *S. centrale*.

Michigan Indicator Species: northern white cedar, sphagnum moss, alder, goldthread, starflower, twinflower, creeping snowberry, one-flowered pyrola, sedge (*Carex gynocrates*), yellow lady's slipper, and showy lady's slipper.

Other Noteworthy Species: Rich conifer swamp provides habitat for sixteen rare plant and fifteen rare animal species. Rare species are listed below along with their status, which is indicated by the following abbreviations: X, extirpated from state; E, State Endangered; T, State Threatened; SC, State Species of Special Concern. Rare plant occurrences tend to be more frequent when the community occurs in association with northern fen or along the Great Lakes shoreline as part of a wooded dune and swale complex.

Rare species associated with rich conifer swamp.

Scientific Name	Common Name	Status
<u>Plants</u>		
<i>Amerorchis rotundifolia</i>	round-leaved orchis	E
<i>Aster modestus</i>	great northern aster	T
<i>Calypso bulbosa</i>	calypso orchid	T
<i>Carex heleonastes</i>	Hudson Bay sedge	E
<i>Cypripedium arietinum</i>	ram's head orchid	SC
<i>Empetrum nigrum</i>	black crowberry	T
<i>Erigeron hyssopifolius</i>	hyssop-leaved fleabane	T
<i>Gymnocarpium robertianum</i>	limestone oak fern	T
<i>Lonicera involucrata</i>	black twinberry	T
<i>Mimulus glabratus</i> var. <i>michiganensis</i>	Michigan monkey-flower	E
<i>Parnassia palustris</i>	marsh-grass-of-Parnassus	T
<i>Pinguicula vulgaris</i>	butterwort	SC
<i>Ranunculus lapponicus</i>	Lapland buttercup	T
<i>Senecio indecorus</i>	rayless mountain ragwort	T
<i>Stellaria crassifolia</i>	fleshy stichwort	E
<i>Vaccinium vitis-idaea</i>	mountain-cranberry	E
<u>Animals</u>		
<i>Accipiter gentilis</i>	northern goshawk	SC
<i>Alces americanus</i>	moose	SC
<i>Appalachina sayana</i>	spike-lip crater	SC
<i>Asio otus</i>	long-eared owl	T
<i>Buteo lineatus</i>	red-shouldered hawk	T
<i>Canis lupus</i>	wolf	T
<i>Falci pennis canadensis</i>	spruce grouse	SC
<i>Felis concolor</i>	cougar	E
<i>Glyptemys insculpta</i>	wood turtle	SC
<i>Hendersonia occulta</i>	cherrystone drop	T
<i>Lynx canadensis</i>	lynx	E
<i>Pandion haliaetus</i>	osprey	SC
<i>Picoides arcticus</i>	black-backed woodpecker	SC
<i>Sistrurus c. catenatus</i>	eastern massasauga	SC
<i>Somatochlora hineana</i>	Hine's emerald	E



Conservation and management: Rich conifer swamp is one of the most floristically diverse natural communities in the upper Midwest. It provides habitat for more than 25% of northern Michigan's wildlife species and critical winter yards for deer (Doepker and Ozoga 1990). They also provide important habitat for over 30 rare species. Their unique structure and high diversity contributes significantly to the overall biodiversity of the northern Great Lakes region. In addition to their importance to biodiversity, they are also one of the region's most economically important natural communities (Grossman and Potter-Witter 1990).

Rich conifer swamp is considered a self-maintaining, stable community that relies on gap dynamics to regenerate long-lived, shade-tolerant, northern white cedar (Curtis 1959). The community occurs in a region where deer were scarce prior to logging in the mid-1800s (Van Deelen et al. 1996). Because northern white cedar is a main winter-staple of deer in northern Michigan, and deer tend to yard in cedar swamps during the winter (Verme 1965), historically high deer densities for the region have led to a decline in the community's ability to naturally regenerate (Van Deelen et al. 1996).

In the absence of herbivory by deer, northern white cedar readily regenerates through both layering and seedling establishment (Verme and Johnston 1986). Northern white cedar is slow growing and can require 20 to 40 years, depending on site conditions, before attaining heights where it can withstand intense browsing (Verme and Johnston 1986). Seedlings may die when more than 20% of their foliage is removed and are especially vulnerable to herbivory when above the snow line. In several rich conifer swamp-deeryards, random sampling detected no seedlings of northern white cedar over 30 cm in height (i.e., above the snow line), while 868 seedlings were found in the smaller size classes (i.e., below the snow line) (Van Deelen 1999).

To encourage regeneration of northern white cedar, several authors provide detailed recommendations that involve harvesting cedar swamps in a series of large blocks (16 to 24 ha, 40 to 60 acres) using either staged strip-cuts, or 2 to 4 hectare (5 to 10 acres) clearcuts (Verme 1965, Verme and Johnston 1986). Prescribed burning within the clearcut blocks is also advocated when advanced regeneration of northern white cedar is lacking and as a method for reducing competition (Verme and Johnston 1986). They strongly emphasize that the success of these methods will largely depend

on keeping deer away from the treated area during the establishment phase of northern white cedar (20 to 40 years). However, a recent study of deer ecology demonstrates the difficulty of this task (Van Deelen 1999).

Using radio collars to evaluate deer movement, Van Deelen (1999) determined that nearly half the animals continued to utilize deeryards throughout the growing season. In addition, most deer stay within the deeryard until early April, when seedlings in recently cut blocks or strips are fully exposed and susceptible to over-browsing. Lastly, deer ranges during mild winters, which are increasingly the norm, were frequently 195 to 212 hectares (482 to 524 acres) in size, indicating that they move between multiple patches of cedar swamp. Thus, it may be difficult to keep deer away from recently cut blocks or strips long enough for northern white cedar to regenerate without simultaneously reducing regional deer densities. These findings suggest that it may take a coordinated, regional approach involving multiple partnerships to address the long-term sustainability of rich conifer swamp.

Van Deelen (1999) recommends developing diversity management areas (Alverson et al. 1994) based on deeryard-summer range pairings. Within these areas he suggests managing deer herds at lower densities, and allowing natural disturbance regimes such as gap dynamics to create habitat for late-successional species, which may be absent from more intensively managed landscapes.

The frequent conversion of rich conifer swamp to hardwood-conifer swamp, hardwood swamp, aspen, and alder thicket following logging is also a concern. Verme and Johnston (1986) recommend prescribed burning following clearcuts in cedar swamp to help setback advanced regeneration of hardwoods and other conifers, and improve seedling establishment by northern white cedar.

At present, few exotic species occur within the community. However, marsh thistle (*Cirsium palustre*) and bittersweet nightshade (*Solanum dulcamara*) occur in many rich conifer swamps. The exotic species with the greatest potential to alter community structure and function at this time is glossy buckthorn (*Rhamnus frangula*). This species has invaded similar habitats in the eastern Upper Peninsula, southern Michigan, and Wisconsin. Once established, glossy buckthorn can be very labor intensive to control (Reinartz 1996).



Research needs: The lack of northern white cedar regeneration is a concern shared by many. More studies are needed that document the effects of deer on northern white cedar regeneration, overall floristic diversity, and their secondary impacts on other animal species. Because many second growth cedar swamps established following logging-era slash fires when deer were relatively scarce, studies on stand structure and ages of second growth northern white cedar in relation to other tree species will improve our understanding of successional patterns and conditions for favorable cedar swamp development (Pregitzer 1990).

The effects of fire suppression on tree species composition of the surrounding landscape may also be worthy of detailed study. In the Interlobate Region of southern Lower Michigan, for example, fire-sensitive red maple has become widely established in formerly fire-dependent, oak-dominated uplands and is now rapidly colonizing tamarack swamps, hastening their conversion to hardwood swamp (Kost 2001b). Because northern white cedar is slow growing and quickly over-topped by hardwoods such as red maple, fire suppression may be facilitating the conversion of cedar swamp to hardwood-conifer swamp by failing to reduce the abundance of fire-sensitive tree species within adjacent uplands.

While northern white cedar may be able to co-exist for an extended period under a hardwood-dominated canopy, its slow growth rate relative to other species puts it at a distinct disadvantage for seedling and sapling colonization of light gaps. Studies of northern white cedar regeneration relative to gap size and variable deer densities may provide very practical information on managing cedar swamps for long-term sustainability.

Similar communities: Rich tamarack swamp, hardwood-conifer swamp, poor conifer swamp, northern hardwood swamp, boreal forest, wooded dune and swale complex.

Other Classifications:

Michigan Natural Features Inventory Pre-settlement Vegetation (MNFI):

Lowland Conifer – Cedar (4231)

Michigan Department of Natural Resources

(MDNR): C - northern white cedar; Q - mixed swamp conifers

The Nature Conservancy U.S. National Vegetation Classification and International Classification of Ecological Communities (Faber-Langendoen 2001, Natureserve 2002):

CODE; ALLIANCE; ASSOCIATION; COMMON NAME

I.A.8.N.g.6; *Thuja occidentalis* Saturated Forest Alliance; *Thuja occidentalis* - (*Picea mariana*, *Abies balsamea*) / *Alnus incana* Forest; White-cedar – (Mixed Conifer) / Alder Swamp

I.A.8.N.g.6; *Thuja occidentalis* Saturated Forest Alliance; *Thuja occidentalis* – (*Larix laricina*) Seepage Forest; White-cedar Seepage Swamp

Related Abstracts: boreal forest, hardwood-conifer swamp, northern hardwood swamp, rich tamarack swamp, wooded dune and swale complex, round-leaved orchis, secretive locust, calypso, ram's head lady's slipper, limestone oak fern, Michigan monkey-flower, marsh grass-of-parnassus, black-backed woodpecker, Lapland buttercup, northern goshawk, red-shouldered hawk, wood turtle, eastern massasauga, Hine's emerald dragonfly.

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- Abstract Citation:** Kost, M.A. 2002. Natural community abstract for rich conifer swamp. Michigan Natural Features Inventory, Lansing, MI. 10 pp.

Updated June 2010.

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Funding for abstract provided by Michigan Department of Natural Resources - Forest, Mineral, and Fire Management Division.

